time, as presenting a condensed criticism of all that had been effected in this direction; this paper was originally read to the council, in support of Bessel's claim to the gold medal for "his assumed discovery of the parallax of the remarkable star 61 Cygni." In 1845 Mr. Main procured the reduction of the numerous sextant observations of the great comet of 1843, the results of which were presented in a memoir read in January, 1846; but they did not justify, in point of precision, the time and trouble which had been expended upon them. In a paper read March, 1849, Mr. Main gave his deductions on the ellipticity and form of the planet Saturn, from measures at the Royal Observatory, showing that there is not, as was suspected by Sir William Herschel, any sensible deviation from a perfect ellipse. In April, 1856, he made a communication on "the values of the diameters of the planets having measurable discs," embodying observations with a double-image micrometer, extending from 1840 to 1852. His subsequent contributions to the same memoirs are (1) "On the Value of the Constant of Refraction" (1857); (2) "On the Proper Motions of the Stars of the Greenwich Catalogue of 1576 Stars for 1850" (1858), (3) "On the Value of the Constant of Aberration" (1860). Mr. Main successively filled the offices of Secretary and President of the Royal Astronomical Society.

As Radcliffe Observer Mr. Main has most conspicuously maintained for the Oxford establishment the high reputation with which it was left by his energetic and respected predecessor, Mr. Johnson. The successive volumes of observations have appeared with marked regularity, Mr. Main himself taking a much more active part in the routine computations than is usual for the director of an observatory, with the view of insuring with his comparatively small force this desirable result. Of the great value attaching to the Radcliffe observations it is unnecessary to speak here. We will only express the hope that the future conduct of the Institution may render as valuable services to practical astronomy as in the hands of Johnson and Main it has done in the past.

THE NATIONAL WATER SUPPLY

NEXT to a Conference of European powers deliberating on the fate of nations, it is difficult to imagine a Congress which may possibly more largely affect the welfare, health, and life of the people, than that to be held at the Society of Arts next week, on the subject of Water Supply.

The Congress is called at the instigation of His Royal Highness the Prince of Wales, to consider his proposition "how far the great natural resources of the kingdom might by some large and comprehensive scheme of a national character, adapted to the varying specialties and wants of districts, be turned to account not merely of a few large centres of population but for the advantage of the nation at large."

To inquire into these resources has been one of the objects of various Royal Commissions, which, though conducted with great ability, a lavish expenditure of time, and successful in collecting a large amount of very valuable information, have all failed to recommend how these bountiful stores of water can be made available. They found in the words of the Rivers' Pollution Commissioners "that an inquiry into the water supply of provincial towns must be one of great magnitude, involving a large amount of statistical and topographical investigation over the whole kingdom."

The Duke of Richmond's Commission, 1868-9, found it impossible, without further powers to carry out the inquiry, but they express their decided opinion "that the Legislature should jealously watch any proposal for a town taking water from a gathering ground at a distance from it, lest by so doing it may deprive other places nearer to such gathering ground of their natural source of supply;" and further, "that when any town or district is supplied by a line of conduit from a distance provision ought to be made for the supply of all places along such a line." This last suggestion has been adopted by the Select Committee of the House of Commons, lately ordered to "report upon the present sufficiency of the water supply of Manchester and its neighbourhood, and of any other source available for such supply," who recommend that the towns along the route of the proposed aqueduct from Thirlmere to Manchester be allowed a supply, after Manchester has been provided with twenty-five gallons per head. It is a source of regret that this Committee did not avail themselves of their full powers to inquire into all the means existing of supplying Manchester, as even should the Thirlmere scheme have proved the best, the information gained might have been useful to other districts. For though it is advisable that the inhabitants of Manchester, being accustomed to soft water, should continue to receive it, hard would probably be found equally wholesome, if pure, to those populations they propose to supply that are not at present using soft water.

Three points will probably be uppermost at the Congress—(1) Evidence to show the stores of water available; (2) How far the existing water legislation requires amendment, so as to give cheaper and quicker water powers to sanitary authorities than at present; and (3) How far it is advisable to have a National Water Supply Survey of the whole kingdom in connection with the Department of Health, technically known as the Local Government Board.

Looking to the fact that the labours of the various Royal Commissions and Select Committees have failed to recommend a scheme of provincial water supply, it is perhaps too much to hope that the present Congress will succeed; but when it is remembered that these failures prove the absolute necessity of personal examination of each district, and finding for each a scheme suited to its special requirements, we may look forward to this experience being utilised, and a scheme elaborated in which a scientific inspection of the country will play a principal part.

At this juncture it may not be without interest to glance at the present sources of supply of some of our great centres of population, and the means that are being taken to increase it.

The older palæozoic rocks forming the elevated tracts of the English Lake District, the Scottish and Welsh Hills, and Dartmoor, all of which are practically impermeable to water, lie west of a line ranging through the mouth of the Exe on the south coast, to the mouth of the Tyne on the north-east coast, and it is west of this line that the largest rainfall is received, ranging from 40 to 150 inches per annum. The rapid slopes and impermeable nature of the ground on which it falls cause it to be nearly all carried off in floods often of the most destructive character, and exceeding the dry weather flow 500 and even 1,000 times; the floods in the Silurian mountain districts amounting, according to Mr. Bateman, to a volume of 200 to 500 cubic feet of water per second derived from each 1,000 acres of area, while in dry weather the water given off by peat-mosses, and the unimportant springs found in such districts, will only amount to from one-fourth to three-fourths of a cubic foot per second.

The enormous volumes of pure water which run off the Westmoreland and Cumberland Mountains are stored to a certain extent in the numerous lakes which traverse that district, occupying true rock basins and often attaining a greater depth than the English Channel between Folkestone and Boulogne. Engineers have from time to time proposed them as sources of water supply for the crowded population of Lancashire, and even for the metropolis, and at length the House of Commons has assented to Mr.

Bateman's project of taking Thirlmere for the additional requirements of Manchester and the towns on the line of aqueduct. The rainfall is stated to be 98 inches per annum, which it is calculated will afford a supply of 64 million gallons a day, of which more than 13½ will be given back to the streams as compensation. The route to Manchester is 102 miles in length, the Lune will be crossed five miles above Lancaster, the Ribble five miles above Preston by pipes capable of conveying in the first instance, 10 million gallons a day; but the covered aqueduct from Thirlmere to the service reservoir at Bolton, will be large enough to convey 50 million gallons per day. The estimated cost of the first instalment of water will be 1¾ millions.

At present Manchester is supplied by a series of reservoirs collecting the rainfall of 18,000 acres of lower carboniferous rocks, consisting of permeable sandstones and impermeable beds of shale, which latter support the water absorbed by the pervious overlying strata. This water is not conveyed away down the dip planes of the strata, into other water-sheds, but is returned to the surface of the basin in which it falls; so that out of 45¾ inches of rainfall no less than 33 have been collected in the reservoirs. The supply from these Longdendale reservoirs will very nearly reach 25 million gallons daily, or 25 gallons per head of the existing population of Manchester and district, without any additional supply from Thirlmere.

In the Liverpool Gravitation Waterworks area, in the Rivington district, the geological conditions are similar; the drainage area is 10,000 acres, the average rainfall is 46 inches, and the mean from 1861 to 1865, was 44 inches, of which 33½ were collected, leaving 10½ inches for evaporation and absorption. Part of the Liverpool supply is derived from wells in the New Red Sandstone, the Green Lane Well having yielded no less than 3¼ million gallons per day.

The New Red series occupies an area in England of 7,431 square miles, absorbing on an average 10 inches of rain annually, or 400,000 gallons per day, for each square mile of surface, and affords over nearly the whole of the district an abundant supply of water which is described by the Rivers' Pollution Commissioners as "almost invariably clear, sparkling, and palatable, and amongst the best and most wholesome waters for domestic supply in Great Britain."

The great importance of the New Red Sandstone as a source of pure water makes its southern and eastern range under the newer formations a matter of some interest. At Scarle, near Lincoln, in a boring that attained a depth of 2,030 feet and reached carboniferous strata, it was passed through and was 786 feet thick, affording a very plentiful spring of water, which rose six feet above the surface.

Southwards the New Red series rapidly thins, but the thin end of the wedge is present at Burford, west of Oxford, where true coal measures have been reached beneath them; and still further south, at Crossness, the new boring of the Metropolitan Board of Works, after penetrating the Gault with its phosphatic basement bed, with the characteristic *Ammonites interruptus*, traversed certain red beds which are possibly referable to the Trias, and which would probably, if bored through, be found to be not less than 178 feet thick.

The Commissioners comment very favourably on the character of the waters derived from the Oolites, the volume of which is immense, the "Seven Wells," forming the head waters of the Churn, yielding two million gallons daily; the Syreford spring four millions, issuing at the base of the Inferior Oolite; other powerful springs in the Fuller's earth yield twelve and even twenty million gallons per day, which might be made available for the supply of Oxford, and other towns on the Thames, as Prof. Prestwich has ably pointed out in his "Oxford Water Supply." The Thames, above this city at Wolvercot, has an average daily summer flow of seventy-three million gallons, increasing to 742 million gallons in winter floods, which proves the quickness with which the Oolitic waters are given off, the amount absorbed by the rock being probably nearly all returned to the Thames basin, its onward progress down the dip planes of the strata towards London being stopped by lines of fault. Three million gallons of water are pumped from these oolites by the Thames and Severn Canal Company, and most of this water finds its way into the watershed of the latter river.

The Lower Greensand and Upper Greensand both yield large supplies of pure water to a large district in the south-east of England; they were proved in the deep boring at Meux's brewery, to overlie the true Devonian,[1] which rises there and form the old palæozoic ridge under the London basin. At the new boring at Crossness the lower greensand was absent, but the gault is so constantly unconformable to the lower cretaceous strata, and rests in the south-west of England on various members of the oolitic and liassic strata, that its occurrence on the red rocks of probably triassic age at Crossness is not specially remarkable, but would merely indicate more extensive denudation of the older secondary rocks there, than at Meux's brewery. This, should Mr. Godwin Austen's view of the possible continuation in that area of the Belgium and South Wales coal-field be correct, would have the effect of shortening the vertical distance to the coal-measures under the Thames basin. Be this as it may, both from the scientific and economic questions involved, it is a matter of considerable importance that the Crossness boring should be continued, and the nature of the underlying rock cleared up.

In the metropolis, Col. Bolton reports that in the month of June, 1877, the average daily quantity of water supplied by eight companies was 132½ million gallons to 3,796,000 people, living in over half a million houses, or a little less than thirty-five gallons per head during that summer month. The average daily quantity required is 125 million gallons, according to Mr. Bramwell, who proposes that London should receive an additional supply derived from wells drawing their supplies from the deep springs of the chalk, which he calculates would easily yield sixteen to thirty million gallons per day, which he would store in four reservoirs, north and south of London, at an elevation of 400 feet above ordnance datum, from which he proposes to give a separate supply for potable and fire-extinguishing purposes, at an estimated cost of 5½ millions.

Prof. Prestwich has pointed out that the first settlement of the London area was on the water-bearing gravel beds, the suburbs extending in the direction of these gravels, and that all extension stopped short at the outcrop of the London clay; but so soon as water companies introduced a supply of water derived from other areas, the northern side of London was built over. In Lancashire the middle glacial sands and gravels have taken the place of the gravels of the London area, and every exposure of sand rising through the boulder clay, marks the site of an ancient town or village, as Preston, Lancaster, Kirkham, Euxton, Leyland, Wigan, and Chorley, and numerous others.

London received its first systematic water supply in 1581 direct from the Thames, pumped by a water wheel placed in one of the arches of London Bridge by Peter Morrys, an ingenious Dutchman. This continued to afford a supply for two hundred years, and with the New River, brought by Sir Hugh Myddelton in 1613, from the chalk springs of Herts, satisfied the requirements of the metropolis up to 1723, when the Chelsea Water Works were established, followed by the Lambeth in 1785, the West Middlesex in 1806, and the Grand Junction in 1820, all taking their supplies from the Thames. Iron

[1] Determined from the fossils by Mr. Etheridge, F.R.S.

street pipes in lieu of wooden ones were introduced at the end of the last century, and the plan of filtration in 1829 by the Chelsea Company.

The tidal portion of the Thames at Hammersmith and Kew afforded a supply only thirty years ago, until the companies were at length compelled to take their supplies from above Teddington Weir, so as to be out of tidal influence. Five London Water Companies have the power to draw about 110,000,000 gallons per day from the river; its minimum flow during the minimum month of dry years is 350,000,000 gallons per diem. Mr. Beardmore estimates the amount of rainfall run off the Thames basin above Kingston from 1850 to 1868, to give a mean annual rate of 7·83 inches, while the mean rainfall at Oxford was 26·08, the rest of the rainfall being evaporated, or absorbed by vegetation. The head waters of the Thames are maintained by springs of the oolites, but these lose their volume after drought, the dry-weather flow of the river being maintained by the deep-seated springs of the chalk, which occupies an area in the Thames Basin, above Kingston, of 1,047 square miles, and has, according to Mr. Beardmore, a storing capacity of sixteen months.

Large numbers of wells have been sunk in the metropolitan area during the present century, into the Thanet Sands, underlying the London Clay; as these by pumping became exhausted, the chalk was penetrated, and the rainfall which is absorbed in the Hertfordshire and Surrey Hills, and flows down the dip planes of the strata under the London clay of the Thames Basin, was pumped up by the brewers and other large consumers. The constant tax, however, on this supply has caused a steady and increasing depression in the level to which the water will rise, and has necessitated in many instances the lowering of the pumping machinery in the metropolis.

Eighteen million gallons[1] daily of water of the River Lea that would have naturally gravitated towards London is intercepted by the New River Company, who pump their chalk wells most, when the River Lea is driest, and thus draw upon the deeper springs, which would not in ordinary course have reached the surface in that area.

Following the example of some 100 or more provincial towns that have acquired the control of their own waterworks, the Metropolitan Board of Works have laid before Parliament a bill to acquire the rights of the whole of the London water companies, which, at twenty years' purchase, are valued at fifteen million pounds, an amount steadily increasing, and have coupled it with another bill, to give effect to Messrs. Bramwell and Easton's proposal to sink chalk wells for a separate supply for drinking purposes. Influenced probably by the enormous cost of the one scheme, and the inconvenience attendant on the laying of 2,600 miles of new pipes in the other, the proposals are not supported by the ratepayers, who appear to consider "living organisms" in the water now supplied to them a minor evil. The "purchase bill" is now, however, abandoned for this session, and the "well scheme" will probably rest for the present.

An extension of Mr. Bateman's project for bringing the Vyrnwy and other head waters of the Severn to the metropolis, has recently been suggested for the future requirements of Liverpool, sixty miles distant; the watersheds between the Mersey, Dee, and Severn basins are very low, so that little tunnelling would be required. The scheme is stated by Mr. Hugh Williams, who suggested it, to be capable of yielding, if required, no less than 193,000,000 gallons of water daily, after allowing for compensation, a quantity which would suffice for the wants of six millions of our population, and could not fail to have a salutary influence on the floods of the Severn.

CHARLES E. DE RANCE

[1] The New River also receives 3½ million gallons daily from the Chadwell Spring, and the water obtained from various wells in the chalk.

NOTES

SINCE our last number appeared American science has sustained a loss which will be universally deplored. Prof. Joseph Henry, the Director of the Smithsonian Institution, whose labours for the progress of science, all the world over, have been increasing, is no more. We shall take an early opportunity of referring to his long-continued labours for the furtherance of natural knowledge among men.

WE understand that Mr. E. Roberts, of the *Nautical Almanac* office, has been requested by the India office to construct for use in India a self-acting tide-calculating machine. It will be designed not only to predict the tides at open-coast stations, but also river and shallow-water tides. It will be a great improvement on the tide-calculating machine at South Kensington (now temporarily at the Paris Exhibition), inasmuch as the tides caused by the smaller lunar perturbations will be included. Each component will be fitted with a slide, so that no error will be caused from the excentricity of the pullies. The ordinates of the curves traced by the machine being as much as eighteen inches, the use of the slides is imperative. Mr. Roberts has calculated new numbers to represent the periods of the many components, and with such success, that the actual error of any one component, after a run representing a year's predictions, will not exceed the limit of error of setting the component at the commencement. The machine will be fitted with self-regulating driving-gear, so that it can be set at the close of the day and the whole year's curves be ready for reading off by the next morning. The machine is expected to be finished towards the end of the year. Now that the immense labour (the only objection raised against the employment of tidal predictions by harmonic analysis) is superseded, it is to be hoped that the Admiralty will avail themselves of an instrument, the results of which are so vastly superior to those now obtained with considerable labour by actual computation.

PROF. HUXLEY has been elected a corresponding Fellow of the Royal Academy of Rome, in the Department of Natural History.

WE learn that the following gentlemen, all highly distinguished for their numerous original researches and published memoirs on physiological and systematic botany, have recently been elected foreign members of the Linnean Society of London:—viz., Prof. Teodoro Caruel, of Pisa, Dr. Ernest Cosson, of Paris; Dr. George Engelman, of St. Louis, Missouri, U.S.; Prof. Eduard Fenzl, of Vienna; and Prof. Julius Sachs, of Würzburg.

ON April 29 a monument, in memory of the great physicist, Alessandro Volta, was unveiled at Pavia. Most of the Italian Universities, and several foreign scientific societies had sent deputies to Pavia University for this event. The monument is a masterpiece of the sculptor Tantardini of Milan. The ceremony of unveiling was followed by a dignified celebration at the University, and upon that occasion the following gentlemen were elected honorary doctors of the scientific faculty: Professors Clerk Maxwell (Cambridge) and Sir W. Thomson (Glasgow); M. Dumas (Paris), Dr. W. E. Weber (Leipzig); Professors Bunsen (Heidelberg) and Helmholtz (Berlin), Dr. F. H. Neumann (Koenigsberg), and Dr. P. Riess (Berlin).

THE death is announced of Roberto de Visiani, "the Nestor of Italian botanists," Professor of Botany at Padua, aged seventy-eight.

WE notice the death in Berlin on April 22 of the well-known astronomer Prof. Wolfers. For many years he was connected with the Berlin Observatory, and, as editor of the *Jahrbuch* issued from this institution, he has for the past forty years rendered services of the greatest value to astronomy. His re-